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<p>(21) International Application Number: PCT/DK99/00706 (22) International Filing Date: 16 December 1999 (16.12.99) (30) Priority Data: PA 1998 01650 16 December 1998 (16.12.98) DK (71) Applicant (for all designated States except US): NKT FLEX- IBLES I/S [DK/DK]; Priorparken 510, DK-2605 Brøndby (DK). (72) Inventors; and (75) Inventors/Applicants (for US only): GLEJBØL, Kristian [DK/DK]; Kvædehaven 109, DK-2600 Glostrup (DK). RYTTER, Jan, Christian [DK/DK]; Kastrupvej 14, 4. tv., DK-2300 Copenhagen S (DK). (74) Agent: NKT RESEARCH CENTER A/S; Priorparken 878, DK-2605 Brøndby (DK).</p>		<p>(81) Designated States: AE, AL, AM, AT, AT (Utility model), AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, CZ (Utility model), DE, DE (Utility model), DK, DK (Utility model), DM, EE, EE (Utility model), ES, FI, FI (Utility model), GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SK (Utility model), SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).</p> <p><b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments. In English translation (filed in Danish).</i></p>
<p>(54) Title: ARMOURED FLEXIBLE PIPE AND USE OF SAME</p> <div data-bbox="397 1155 1136 1396"></div> <p>(57) Abstract</p> <p>An armoured flexible pipe has an inner liner (3) surrounded by a pressure armour (5, 6) that is surrounded by a tensile armour (7, 8). The pressure armour (5, 6) is constructed from a number of profiles (5, 6, 10, 11, 12, 14, 14a, 14b, 14c) which may engage with each other. In order to obtain optimum functionality, the profiles are shaped as X profiles (14, 14a, 14b, 14c) which are kept together with another type of profile, e.g. C or T type profiles. In one embodiment, the X profiles have an open channel (17). In this way gas or liquid, such as rinsing fluid, may be pumped through the armour layer, from one end of the pipe to the other end. In particular, the armoured flexible pipe is useful for conveyin g fluids such as water, ammonia, hydrocarbons, etc.</p>		

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Armoured flexible pipe and use of same.

5 The invention relates to an armoured flexible pipe comprising an inner liner surrounded by a pressure armour comprising a number of helically wound profiles, on the outside of which a number of profiles are mounted.

The invention further relates to a use of the pipe.

10 Usually, pipes of the above-mentioned type comprise an inner liner forming a barrier to outflow of fluid conveyed through the pipe.

The inner liner is wound with one or more armour layers which are not chemically bound to the inner liner but may move in relation thereto, thus ensuring the flexibility of the pipe during laying out and operation.

15

An outer sheath is located outside the armour layers in order to form a barrier to inflow of fluids from the surroundings of the pipe into the armour layers.

In order to prevent the inner liner from collapsing, the inner liner is often lined with a flexible, wound pipe, a so-called carcass.

20

The above-mentioned type of flexible pipes is used e.g. for conveying liquids and gasses in different depths of water.

In particular, they are used in situations in which very high or varying water pressures are present along the longitudinal axis of the pipe. A riser pipe extending from the seabed to an installation at or near the surface of the sea is an example.

25

Furthermore, this type of pipe is used between installations located on the seabed at low depths or between installations near the surface of the sea.

30 Some of the armour layers, particularly those that are used as pressure armour, are most often constructed in such a way that they comprise different metal profiles. When wound with a large angle in relation to the longitudinal axis of the pipe, these profiles will be able to absorb radial forces resulting from outer or inner pressure. Thus, the profiles prevent the pipe from collapsing or exploding as a result of pressure and are thus called pressure-resistant profiles.

35

As opposed to this, profiles, especially tensile armour wound with a small angle in relation to the longitudinal axis of the pipe, will not be able to absorb radial forces of any significance but will, in contrast, be able to absorb forces exerted along the longitudinal axis of the pipe. This type of profile is called tension-resistant profile.

5

A problem associated with the use of pressure-resistant profiles is that they are to be mechanically fastened to each other in order to prevent them from being displaced along the longitudinal axis of the pipe, thus destroying the pipe. This mechanical fastening is achieved by designing the profiles in such a way that they are locked mechanically to each other in the spooling process.

10

In accordance with conventional methods, armour elements are used for the pressure armour, which are not symmetrical in two planes but which are symmetrical in one plane or 180° rotation symmetrical about the mass centre of the profile.

15

It is an object of the present invention to set out a new geometry of armour elements superior to conventional designs with regard to the operation of the pipe.

20

The object of the invention is fulfilled by a pressure armour comprising a number of X profiles kept together with profiles of another type.

This type of profile differs from ordinary profile types by being fully or partially symmetrical in two planes substantially perpendicular to each other.

25

In addition, the new design of the armour elements has a cross section with a higher moment of inertia and hence a higher bending torque than conventional designs.

30

In this connection it is noted that the X profile differs further from other profiles in that it cannot be used by itself but only together with other profile types which do not contain a double symmetry in two planes substantially perpendicular to each other.

Moreover, for certain X profiles the coupling of force to the nearest similar neighbours is effected through four lines of forces.

On all known profile types, the transfer of force to the nearest similar neighbours is effected through two lines of forces.

Appropriate embodiments of the profiles used for connecting the X profiles are set out in claims 2-4.

5 The X profile being provided with at least one channel as indicated in claim 5 and the channel in the X profile being suitably located at the side as indicated in claim 6, the channel extending along adjacent edges of the X profile, provide the advantage that fluids may be conveyed in a spiral path along the longitudinal axis of the pipe, which may be established by means of pressurizing media.

10 Moreover, additional appropriate embodiments are set out in claims 7-11.

As mentioned above, the invention also relates to a use.

This use is discussed in further detail in claim 12.

15

In the following, the invention will be discussed in further detail with reference to the drawings, in which:

20

Fig. 1 shows a usual construction of an armoured flexible pipe with its various layers,

Figs. 2-5 show different examples of the composition of known pressure armour for flexible pipes of the type shown in Fig. 1,

25

Fig. 6 shows a profile according to the invention for use in pressure armour,

Figs. 7 and 8 show embodiments of profile assembly according to Fig. 6,

30

Fig. 9 shows another embodiment of the X profile according to the invention, allowing conveyance of undesired or rinsing fluids in a channel along the winding direction of the profile.

Figs. 10 and 11 show further embodiments by assembling of specific X profiles, whereas

Figs. 12 and 13 show further embodiments of the X profile.

Fig. 1 shows a pipe comprising an inner liner 3 surrounding a carcass 1 constituted by a helically wound metallic strip 2 forming an inner pipe. During manufacture, the metallic strip 2 is constructed with flaps engaging with each other so that they lock the individual windings of the metallic strip 2 to each other in such a way that the carcass 1 may be bent  
5 along its longitudinal direction.

As the inner carcass 1 is not sealed, it has a surrounding inner liner 3 to prevent fluids from flowing into or out of the interior of the pipe.

On the outside of the inner liner 3, one or several layer(s) of profiles 5, 6 forming windings with a large angle in relation to the longitudinal direction of the pipe are helically wound.  
10 As a consequence of the large angle, the profiles are primarily capable of absorbing radial forces generated by inner or outer pressure.

Inner pressure occurs during operation of the pipe. Outer pressure is generated partly by hydrostatic pressure of the surroundings and partly by mechanical stress during laying of  
15 the pipe.

Thus, the windings form a pressure armour preventing the inner liner 3 from exploding as a consequence of a high pressure on the inside of the pipe or collapsing as a consequence of a high pressure on the outside of the pipe.

20 Further, as shown in Fig. 1, a tensile armour is provided on the outside of the pressure armour, said tensile armour comprising one or several helically wound layers 7, 8.

An intermediate sheath may be provided between the pressure armour and the tensile armour in order to prevent fluids from migrating between the tensile armour and the pressure  
25 armour.

Finally, these layers are surrounded by an outer sheath 9.

However, as the intermediate sheath, the tensile armour and the outer sheath do not relate to the present invention, they will be discussed no further.  
30

Usually, the pressure armour is constructed by a number of interconnected profiles, e.g. as shown in the figures 2-5.

Fig. 2 shows a pressure armour consisting of profiles 5, 6 which are C shaped and which are thus termed C profiles. Here, the interconnection is achieved by two C profiles engag-  
35

ing with each other. In this way, a locking against movement perpendicular to the longitudinal direction of the profile is obtained.

5 Fig. 3 shows a pressure armour which is coupled together by profiles 10, 11 which are T shaped and which are thus termed T profiles. Here, the coupling together is achieved by two T profiles engaging with each other. In this way, a locking against movement perpendicular to the longitudinal direction of the profile is obtained.

10 Fig. 4 shows a pressure armour which is coupled together by profiles 12 which are Z shaped and which are thus termed Z profiles. The coupling together is achieved by winding the Z profile in such a way that the upper and the lower locking folds engage with each other, resulting in a locking against movement perpendicular to the longitudinal direction of the profile.

15 Finally, Fig. 5 shows a pressure armour which is coupled together by two different types of profiles, i.e. C profiles 5 and T profiles 11.

According to the invention, the pressure armour in a first embodiment, as shown in Figs. 7 and 9, is constructed by X profiles 14 which are coupled together by C profiles 5, 6.  
20 As shown in Fig. 6 in the first embodiment, the X profile itself has four locking folds 16 for engagement with locking folds of profiles of another type.

Since the X profiles are coupled together with C profiles which are arranged symmetrically in relation to the longitudinal symmetry line of the X profile, the X profile is loaded with 4  
25 lines of forces providing a coupling capability so that they are not disconnected as a result of local changes of length of pipe.

Fig. 8 shows a second embodiment of the armour layer, which differs from the embodiment shown in Fig. 7 in that the X profiles 14 are kept together with T profiles 10, 11.  
30 As it will be understood, this construction allows a flow of fluids along the profiles.

A further embodiment of the invention is shown in Fig. 9.

As shown in Fig. 7, the X profiles are again kept together with C profiles 5, 6 in this embodiment. However, the X profile 14a is designed with open channels 17 at the side. The  
35 channels 17 extend along a spiral line along the edge of the X profile.

In this way, the free volume between the X profiles forms a continuous channel from one end of the pressure armour layer of the pipe to the other end of the pressure armour layer. This channel may optionally be used for removing undesired fluids or for introducing rinsing fluids in the pipe. The removal may be controlled e.g. by establishing an appropriate pressure difference between the ends of the pipe.

Fig. 10 shows an embodiment of the X profile which is only affected by two lines of forces. Despite the fact that this use of the X profile does not provide optimum mechanical properties, since the two operating lines of forces are not able to absorb to the same extent moments affecting the X profile, this embodiment may be preferred due to ease of manufacturing.

Fig. 11 shows a further embodiment, wherein the lower part of the pressure armour is held in one X profile. The advantage of this embodiment over that shown in Fig. 10 is that the lower strip is controlled in relation to the strength-providing X profile.

Figs. 12 and 13 show other embodiments of the X profiles, Fig. 10 showing an X profile 14b which is designed "italic". This profile may of course also be coupled together with fitted C and T profiles.

Finally, Fig. 13 shows an embodiment of the X profile 14c, wherein adjacent edges form an angle in relation to the normal to longitudinal axis of the pipe.

It will be understood that the present invention as defined by the claims may be implemented in other ways than those shown above.

Thus, the principles of the invention may be used freely in connection with pipes, in cases in which several of these are coupled together by means of coupling elements, etc.

CLAIMS:  
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- 5 1. An armoured flexible pipe comprising an inner liner surrounded by a helically wound pressure armour, characterized in that the pressure armour is constructed by a number of X profiles kept together with profiles of another type.
- 10 2. A flexible pipe according to claim 1, characterized in that the other type of profile is a C type profile.
3. A flexible pipe according to claim 1, characterized in that the other type of profile is a T type profile.
- 15 4. A flexible pipe according to any of claims 1-3, characterized in that a number of X profiles are kept together by means of twice the number of C profiles and/or T profiles.
5. A flexible pipe according to any of claims 1-4, characterized in that the X profile is provided with at least one channel.
- 20 6. A flexible pipe according to claim 5, characterized in that the channel in the X profile is open at the side.
7. A flexible pipe according to any of claims 1-6, characterized in that the X profile has at least 4 locking folds.
- 25 8. A flexible pipe according to any of claims 1-7, characterized in that the pressure armour is of a material which is fully or partially made of a metal, a metal alloy, or a ceramically reinforced metal material.
- 30 9. A flexible pipe according to claim 8, characterized in that the material contains at least 50% Fe.
10. A flexible pipe according to any of claims 1-7, characterized in that the material is fully or partially made of a polymer or a reinforced polymer.

11. A flexible pipe according to claim 10, c h a r a c t e r i z e d in that the material contains more than 20% reinforcing fibres.

12. A use of an armoured flexible pipe according to any of claims 1-11 for conveying fluids  
5 such as water, ammonia, hydrocarbons, etc.

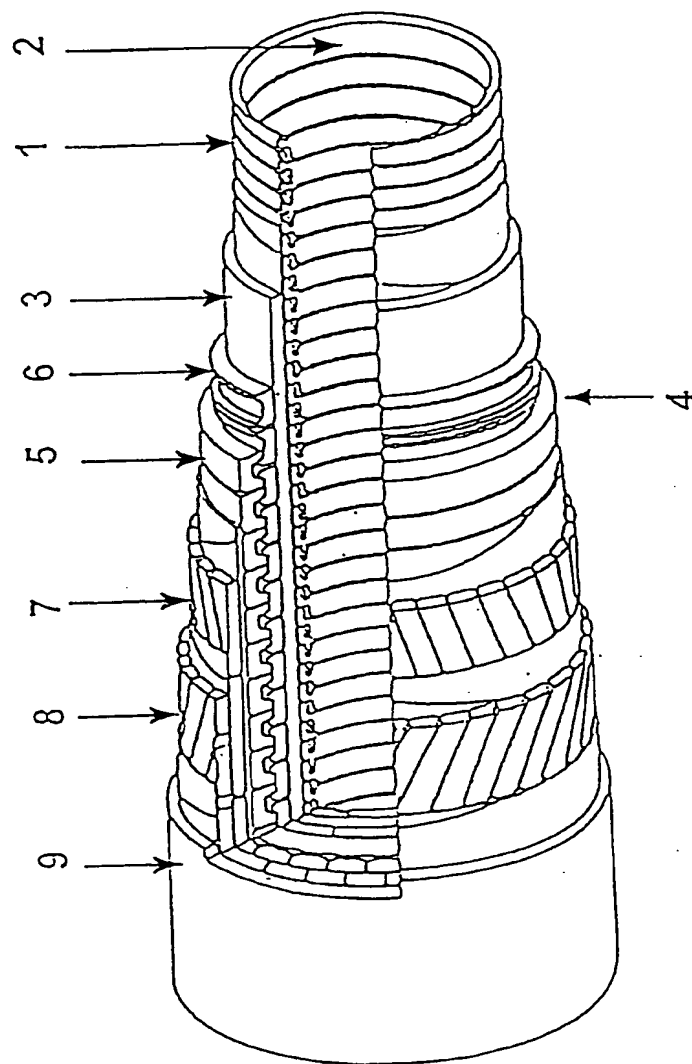


Fig 1

2/5

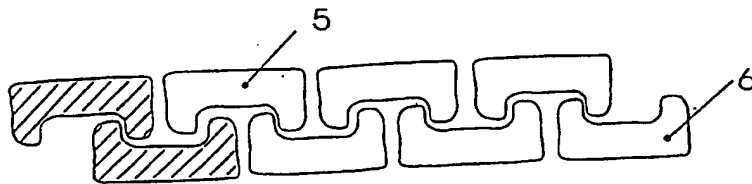


Fig 2

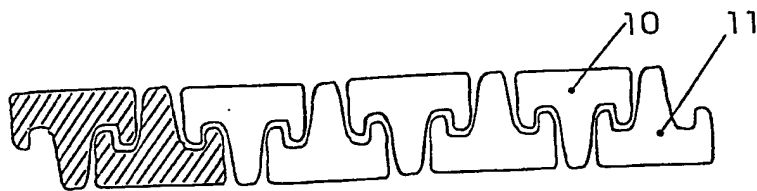


Fig 3

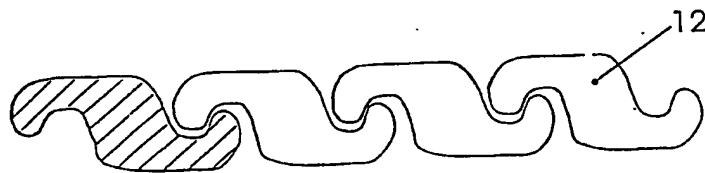


Fig 4

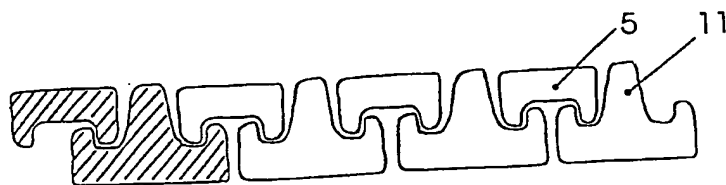


Fig 5

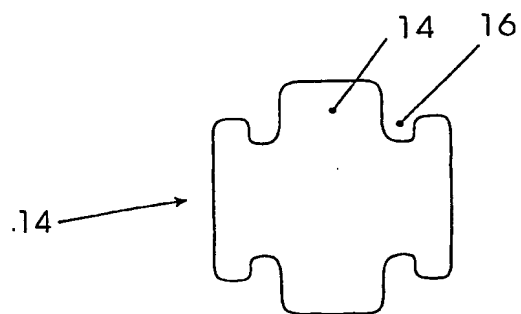


Fig 6

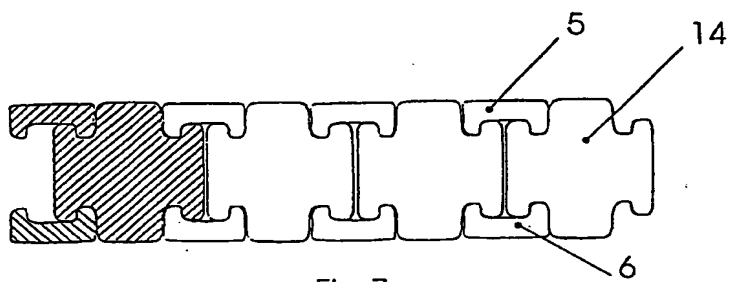


Fig 7

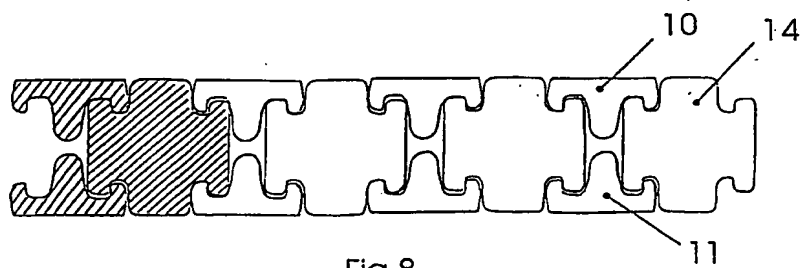


Fig 8

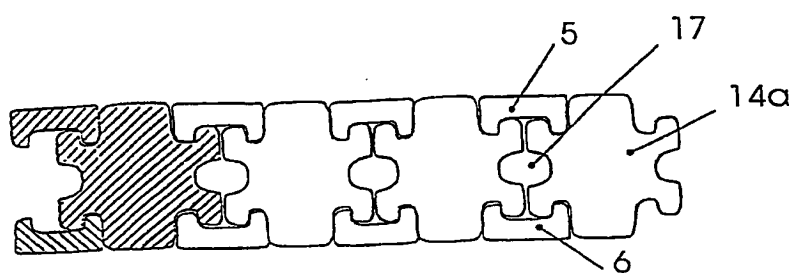


Fig 9

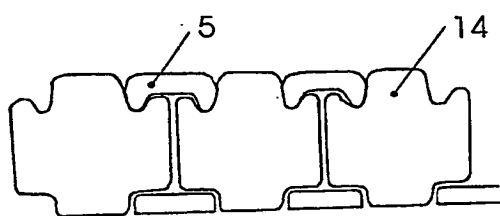


Fig 10

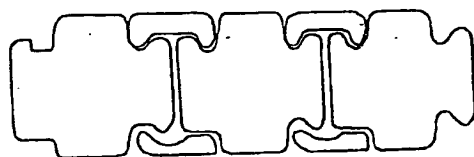


Fig 11

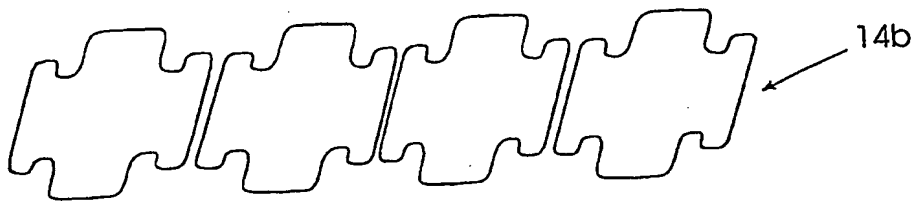


Fig 12

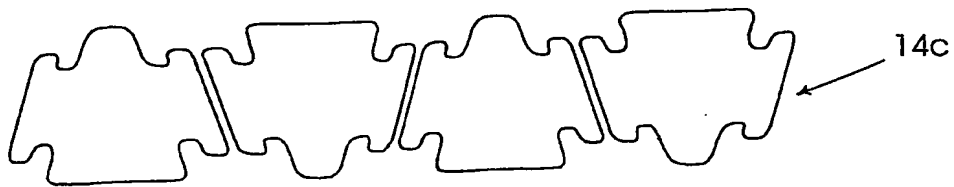


Fig 13

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/DK 99/00706

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: F16L 11/16

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: F16L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 1637141 A (H. COOPER), 26 July 1927 (26.07.27), figure 4  --	1-4,8,12
Y	WO 9100467 A1 (INSTITUT FRANCAIS DU PETROLE), 10 January 1991 (10.01.91), figures 4-9  --	1-4,8,12
A	WO 8911057 A1 (INSTITUT FRANCAIS DU PETROLE), 16 November 1989 (16.11.89), figures 1-4  -- -----	1,12

☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

02/12/99

International application No.  
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Patent document cited in search report			Publication date	Patent family member(s)	Publication date
US	1637141	A	26/07/27	NONE	
WO	9100467	A1	10/01/91	AU 635292 B	18/03/93
				AU 5968890 A	17/01/91
				CA 2027568 A	31/12/90
				DE 6900053 U	14/01/93
				DK 35791 A	28/02/91
				EP 0431142 A,B	12/06/91
				ES 2048497 T	16/03/94
				FR 2650652 A,B	08/02/91
				JP 5503137 T	27/05/93
				NO 301388 B	20/10/97
WO	8911057	A1	16/11/89	AU 626870 B	13/08/92
				AU 3562889 A	29/11/89
				CA 1339726 A	17/03/98
				DE 6890263 U	01/10/92
				DK 4890 A	09/01/90
				EP 0372041 A,B	13/06/90
				FR 2631097 A,B	10/11/89
				IN 173079 A	05/02/94
				NO 301733 B	01/12/97
				US 5275209 A	04/01/94
				US 5406984 A	18/04/95

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